The Response of Fertility to Rainfall Shocks in Rural Ethiopia: Channels and Differential Responses

Endale Kebede

Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/OeAW, WU), IIASA, Schlossplatz 1, 2361 Laxenburg, Austria

Abstract:

The most persistent concern of an agrarian society has always been how to deal with recurrent weather shocks. The demographic responses of families to short-term macroeconomic shocks would provide a proxy measure of respective living standards in settings where direct measures are not adequately available. The few existing studies so far have examined the response of demographic outcomes to macroeconomic crisis in sub-Sahara African countries at aggregate levels. These macro level studies, however, lack details to understand the channels of responses, the differential impact of crisis by socio-economic groups and, hence, to measure their respective living standards. Here, I have analyzed the fertility response of various socio-economic groups to rainfall shocks and the mechanism through which it affect fertility in rural Ethiopia, using a longitudinal data set at the individual level combined with region level time series rainfall data. Less educated, large agricultural land holders and poor families responded strongly to drought induced welfare shocks. Unlike the pre-industrialized western society, there is only a delayed response of fertility to shocks, which evidenced to the absence of planned and deliberate postponement of births-in the face of drought. Instead, births are postponed only involuntarily through malnutrition and/or drought induced temporary separation of spouses.

Introduction

For centuries, whether induced and other macroeconomic shocks has been threatening the welfare of humankind in different space and time. In agrarian society, one of the most pressing concern has always been how to deal with recurrent rainfall shocks and other weather anomalies. In such settings where data on the direct measures of living standards (income and consumption expenditures) are rare or poorly measured, tracing the demographic consequence of short-term macroeconomic shocks would provide an efficient and indirect measures of living standards (Bengtsson et.al, 2004). If you can fulfil your long-term plans—to marry, to have children and to be in good health —in the face of acute changes in your environment, then you have a high standard of living. On the other hand, a person with low standard of living and limited access to consumption smoothing resources can respond only demographically: deliberate or involuntary adjustment of birth timings, out migration, postponement of marriage or may even experience deaths (Bengtsson and Dribe, 2006).

Starting from the Malthusian period, a large number of studies has then been conducted to understand the complex Interrelationships between human behavior and their social and economic environment. There is a near-consensus among the studies on the clear effect of short-term macroeconomic stresses on fertility of the pre-industrialized societies. Malthus (1803) showed that macroeconomic shocks would diminish the resource base of the society and discourage marriage and sexual intercourse, which could led to lower fertility and depletion of population size. Similarly, in the late 20thc, more organized macro level studies had found a strong response of fertility to short-term macroeconomic crisis from the pre-industrialized western society (see, for example, Galloway, 1988; Lee, 1981; Lee, 1990; Bengtsson and Ohlsson, 1985). Lee (1981) explored the response of vital rates to monthly fluctuations in food price from a pre-industrialized England. He found significantly negative and immediate response of births to short-term economic stresses. However, these aggregate level studies lack details to understand the mechanisms through which crisis affect demographic outcomes, to examine the differential impact of crisis by different socio-economic status and, hence, to measure their respective living standards. Weather induced anomalies would not affect all segments of the society uniformly. Large landowners and net agricultural producers would be net beneficiaries, if the price elasticity of demand for food prices were low. On the other hand, landless and non-agricultural laborers would be more adversely affected by the crisis. The timing and magnitude of responses would also be different by the education status of individuals as better-educated individuals could foresee shocks better than less educated counterparts (Muttarak and Lutz, 2014). Thus, recently, scholars are employing a more effective micro level studies, by combining micro demographic data with macroeconomic variables. This enables to examine the fertility response by different socio-economic groups and to trace the timing of responses in details. Most of the micro level studies show that pre industrialized societies had been adjusting birth timings following macroeconomic shocks, albeit the degree of responses was not spread evenly across the population (see, Bengtsson and Dribe, 2006; Bengtsson et al., 2004).

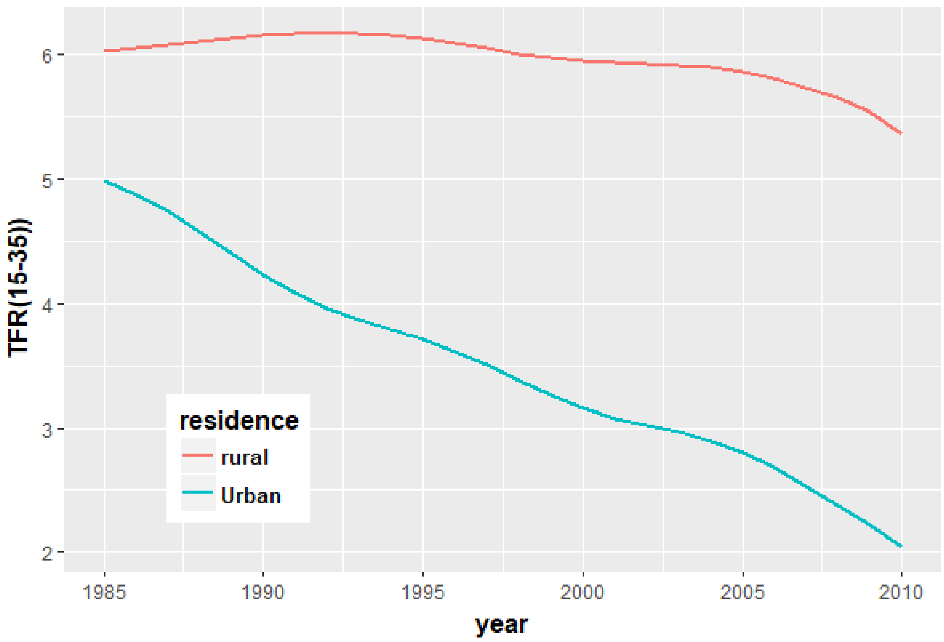
Studies on the demographic responses to macroeconomic changes in sub-Saharan African countries are not only scanty but are at aggregate level which lack details about socio-economic differentiations in the degree and channels of impacts(see, for example: Lesthaeghe, 1989; National Research Council, 1993, Lockwood, 1995; Kinfu, 2000; Kabeer, 2001). The most extensive and comprehensive study on the link between fertility and economic uncertainties in Ethiopia has been conducted by Lindestron and Birhanu(1999). Their study has revealed a strong response of fertility to political and economic uncertainties (civil war, famine and economic decline), during the 1970s and 1980s. However, it did not address the possible differential effects of the crisis on families of different socio-economic status and the mechanisms by which famine and political stress affect fertility: was there a planned and deliberate response to shocks or a passive response. Due to difference in time setting, socio-cultural factors, market integrations, migration possibilities and intervention of government and international communities, the degree and patterns of responses of fertility to crisis would be different between the contemporary agrarian SSA and the pre-industrialized western societies. This paper combined a retrospectively collected longitudinal individual level data, from the most recent Ethiopian demographic and household survey (2016 EDHS), to a region level rainfall data from the climate research unit (CRU) for the period 1974-2016. By doing so, I have investigated the differential responses of various demographic and socio-economic groups and the mechanism through which rainfall shocks affect fertility in rural Ethiopia, where drought is a recurrent event. Our results showed a low standard of living and high degree of vulnerability to shocks in the study area. Unlike the pre-industrialized western society, however, there is only a delayed response of births to shocks, which evidenced to the absence of planned and deliberate postponement of births-in the face of drought. Instead, births are adjusted only involuntarily through malnutrition and/or temporary separation of spouses. Less educated, poor and landed households responded the most to drought induced welfare shocks.

The Study Area/The Ethiopian Context

With a population of more than 100 million, Ethiopia is the second most populous country in Africa and it is characterized by a high annual population growth rate of 2.6 %(United Nations, 2017). It has an agriculture-based economy, which employ more than 80 percent of the population who are mainly small holders who practiced mixed-subsistence farming on the fragmented lands. The sector is largely rain-fed and a modest change in the amount and temporal distribution of the rainfall would cause a considerable decline in crop yields and a rise in grain prices (Admassie, 2013). World Bank (2010) has ranked Ethiopia one of the most vulnerable countries in the world to the adverse effects of climate change. Coupled with deep rural poverty, limited infrastructures and political instability, the effect of recurrent droughts on household welfares are often severe. For example, the 2015-16 El Niño whether event has caused more than 10 % of the population of Ethiopia to urgent food aid. The so-called 'Green-Famine' of the 2002/03 drought in the SNNPR region had caused a 15.5% food price inflation and 14 million people to food aid (EEA, 2005).

The two main crop seasons in Ethiopia are the 'Belg' and 'Meher' seasons, which receive rainfall between June to September and March-May, respectively. Meher is the main crop season when 90-95 percent of the nation's total cereals output is produced (IFPRI, 2012). The Meher crops are sown in May, growing during the main rainy season (June-august) and harvested between September-December. Failure of Meher harvest could usually lead to huge welfare loss and even a famine. The infamous 1984/85 famine, which claimed the lives of a million people and caused serious food shortage to about 8 million people, is associated with the failure of the 1983 meher harvest (Webb, 1992; de Waal, 1991). In this study, thus, I have created an index of drought based on the amount of '*meher*' rainfall as an indicator of short term macroeconomic stresses (see in data section).

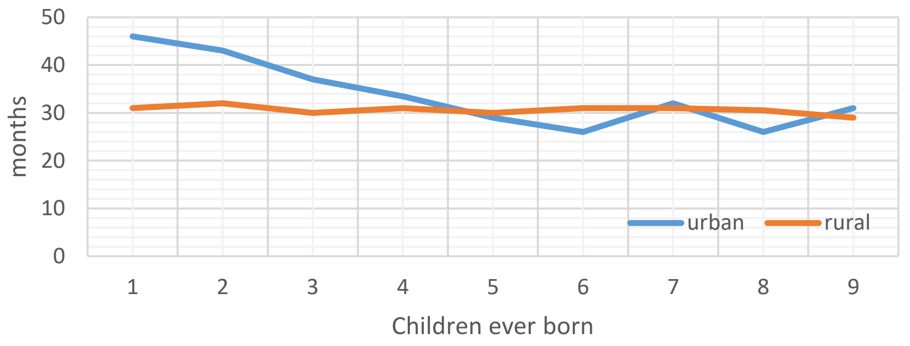
Fig1: TFR(15-35) of Ethiopia by area of residence:1985-2010



Own comoutation from DHSs

Turning to the demographic profile of the country, Ethiopia is one of the high fertility countries in the world. The 2016 demographic and household survey showed that the total fertility rate in the area is about 4.6, with a huge variation by education and area of residence. While the total fertility rate in urban areas (2.3) is about at replacement level, the rural fertility (5.2) is comparable to a sub-Saharan Africa average. This rural-urban gap in total fertility rate is bigger than the African average of about two children per women. Figure 1 shows the period total fertility rate (15-35) of Ethiopia (1985-2010) by area of residence. It revealed that the urban population has been undergoing a fast fertility decline while the rural fertility is at a pre-transitional stage. The number of children the urban woman would bear, between ages 15-35, has declined from about five to two children in just 25 years while the rural fertility changed very little during the same period. Looking at the inter-birth intervals by parity, as displayed in figure 2, rural women has shown no sign of parity specific birth controls despite the low median age at marriage (16.7). In urban areas, on the other hand, the declining inter-birth interval with number of children ever born could be associated with self-selection of high fertility women in to higher birth orders. This study examined the association between birth timing and drought in rural Ethiopia where households depend mainly on farm activities and fertility is at a pre-transitional stage.

Figure 2: Median of Inter birth intervals(Median Number of Months) by number of children ever born



Drought and Birth timing in rural Ethiopia: The Channels

In predominantly agricultural areas of Ethiopia, shortage of summer rainfall would lead to harvest failure in fall with a potential consequence to household's welfare loss: consumption, children education, health and other indicators of living standard would be affected by the shock. However, the degree of vulnerability to crises depend on the characteristics and socio-economic status of the women and her family. That is, individuals varies by age, wealth, asset ownership, source of livelihood, education level , family size , sex and survival status of the previous births and many other factors. For families with little options to respond to shocks, drought induced harvest failures would affect fertility and birth timings in several ways (Bengtsson and Dribe, 2006).

First, a family may deliberately postponed births as the incoming baby require additional caloric intake by the mother and/or the mother need to work harder to cope the shock. Since crops are sown in May and grown in July-August, a family may have a good chance to predict about the harvest already before the end of the summer and practice abstinence, use contraception, not to have a baby during the months when food will be in short, and/or abort conception immediately. Such responses would result in a considerable decline in fertility immediately (within nine months) after the summer. On the other hand, there are several reasons not to expect a deliberate birth control to economic fluctuations in rural Ethiopia:- i) It is a very religious and traditional society where (induced) abortion is illegal and against their religious belief. ii). Majority of the women are illiterate which would limit not only their ability to foresee shocks but their willingness and ability to use family planning services.

Second: Short-term economic crisis may force members of a family to migrate temporarily and cause separation of spouses. In the time of economic difficulties, members of the drought-affected family migrate to nearby cities with the hope of a labor wage, which would enable them to remit back to the families and purchase seeds and farm equipment for the next production season (Dercon, 2002; IFPRI, 2010). "In years of little or off-timing rainfall or when there are extended dry-seasons, crop production can suffer; individual family members migrate as a temporary and strategic adaptation to diversify a household's income and livelihood sources" (Hunnes, 2012). Ezra(2001) indicate that farmers and rural poor of the northern highlands send family members (usually the bread winner) , in search of job, to the sugar and cotton growing rift valley lowlands, where the job is available throughout the year as they practice irrigation and not dependent on the annual rainfall. Similarly, temporary migration to coffee producing south and southeast provinces of the country, following the harvest failure in the crop producing areas, is also common. Land is a state owned asset and the family could lose it if all the members migrate for an extended period. Thus, some members of the family (usually the wife and kids) stay behind. The migrated member would return to his/her village once he earned enough money to buy seeds and other farm equipment for the next production season. Thus, spouse separation is only temporary and fertility is expected to get normal 9-12 months after the partner return back home. Since no one, could afford to lose even small amount of the crop, migration would happen only after the harvest. Thus, failure of summer rainfall, by separating spouses, would have only delayed impact (more than 12 months) on fertility.

Third: In the dry seasons after the harvest failure, there will be serious food shortage and food price would hike. Thus, malnourished partners would reduce sexual intercourse and lowered fecundity. In addition, psychic stress may reduce coitus or lead to amenorrhea. There are a well-documented evidence that whether induced famines had caused serious temporary food shortage in Ethiopia which malnourished and caused for the death of considerable proportion of the society. For example, the 1984/85 famine claimed the lives of 1 million people while the 2003 famine caused serious food shortage for 14 million people. This would force partners to reduce sexual intercourse, reduction of sperm production, loss of libido and hence lower fecundity. Interestingly, the malnutrition effect of economic crisis is not similar across all segment of the society. For instance, in the modest economic decline year of 1999/2000, a percentage increase in food price caused rural households to reduce about 25 Kcal/day while urban households loss only 8-16 kilo calorie per day (IFPRI, 2009).

Data

The primary source of data is the 2016 Ethiopian demographic and health survey. The survey made use of two-stage cluster sampling technique to collect comparable, reliable and nationally representative data on living conditions and demographic characteristics of households. In the first stage, stratification is made by type of residence (urban/rural) crossed by geographic or administrative regions. Within each stratum, the primary sampling units (PSU or clusters) are selected with a probability proportional to their population size, collected from the most recent census. In the second stage, sample households are randomly selected from each cluster. From the selected households, eligible women and men are interviewed using standardized questionnaires, by trained interviewers.

In the demographic and health surveys, all women of childbearing age (15-49) from the selected households are asked about the timing of all births, whether the child survived, and if not, the age in months at which the child died. All women who gave to at least one birth are included in the data set. Because of the close association between marriage decision and firs births, the transition to first births are not considered in the analysis. The combined dataset consists of 25,699 second or higher order births, born in the period 1974 -2016, to 7,491 rural women (level 2) grouped within 10 administrative regions (level 3).

Short-term macroeconomic crisis would not affect all segments of the society uniformly. Households with a consumption smoothing possibilities such as assets and access to financial market are more likely to resist shocks. The DHS contain information on standardized measure of economic status of households-a wealth quintile. It is constructed based on information on assets and services available in the household, excluding education and occupation. We included household wealth status in to the analysis as a categorical variable: poor (those with the first and second quantile), medium (those with the third quantile) and wealthier (those with fourth and fifth wealth quantile). Similarly, in agriculture-based economies, land ownership is an important moderator of the effect of crisis (Lee, 1990). Large landowners and net agricultural producers would be net beneficiaries if the price elasticity of demand for food prices were low. On the other hand, landless and non-agricultural labourers would be adversely affected by the food price crisis (Lee, 1990). In DHSs, the household head reported whether the family own land usable for agriculture and, if any, the size of the land (in hectares). We constructed three group of households based on land ownership status: landless, large landowners (more than 5hectars) and small landowners(less than 5 hectares).

Education is another key social status to predict fertility and vulnerability of an individual or a household to climate related disasters (Lutz et al., 2014). It can influence risk perception behavior of households and help to react and cope risks (Muttarak and Lutz, 2014). DHSs collect information on education of individuals within the household, including highest level of schooling completed. We examined the effect of education of the mother using three levels of educational attainment: no formal education, incomplete primary, completed primary or more.

The demographic transition theory predicted higher fertility associated with child mortality in pre-transitional countries, through child replacement effect and birth spacing. The DHS provide data on the survival status of the previous child, alive or deceased, and age and month of death of the child. We have constructed and included in to our analysis a child level indicator - survival status of previous child: alive, died within two years of birth or died after two years of birth. In addition, we also attempted to control background characteristics of the women, which would predict her fertility decision, such as religion (Muslim or non-Muslim), age at follow-up and number of children ever born.

Rainfall data and Construction of drought indicators

To examine the effect of local rainfall shocks on birth timing, time series data on total precipitation were derived from the climate research unit (CRU) of the University of East Angelia (Harris and Jones, 2017). It provide monthly gridded mean precipitation and temperature data with a resolution of a 0.5 x 0.5 degree grid covering terrestrial areas across the globe, for the period 1901-2015. Monthly precipitation estimates are based on climatologically aided interpolation of available weather station information. We then use the dataset of Global administrative Areas (GADM) to crop and link the CRU monthly time series precipitation data at the administrative region level. This generated a time series monthly rainfall data for the period 1950-2015 for the 10 administrative regions of Ethiopia.

Ethiopia is in the tropical zone laying between the Equator and the Tropic of Cancer and receives the highest amount of rainfall during summer season (June, July and August). The amount and distribution of rainfall during this primary agricultural season (also known as 'kiremt') matters the most to crop yields. We, thus, summed monthly precipitations of June, July and august to create annual series of summer rainfall for each administrative region for the period 1950-2015. To construct our relative measure of drought, we created a gamma distribution of rainfall during the rainy summer season for the period 1950-2015 for each administrative province of the country[1]. We then assign each rainfall realization of a particular province to its corresponding percentile in the distribution. A rainfall shock or drought is defined as a rainfall realization below 15th percentile in the province-specific distribution.

Methods

The effect of local rainfall shocks on fertility were assed with multilevel models in order to account for the hierarchal nature of the DHS data, where children are nested in individual mother, mothers in households, households in clusters and clusters in geographical regions. Because of some sparse observations within households and clusters, I have settled on three level models: children nested in in individual mother and women nested in broader geographical regions. The multilevel modeling allow acknowledging for the correlation of children of the same mother and correlation of mothers with in geographical region.

The main variable of interest in our models is the time (since last birth) to the occurrence of a birth. From the reported birth histories, each women (i) from region (r) was retrospectively followed from the year of birth of the last child ($j-1$) to the birth of the j^{th} child. The follow-up interval (t=1, 2, 3, 4, 5, 6) has equal length of 1 year. To make the dataset manageable, a woman was followed only for six years since the last birth. If a birth has occurred in the k^{th} year (k<=6) since the last birth, then it contributed k observations to the sample. Those births occurred after the sixth year are treated as they have never occurred (right censored) and contributed six observations to the sample. Since the survival times (follow-up intervals) is a discrete variable, I have fitted multilevel logistic regression models. The baseline model is specified as:

$$\text{Logit}\left(\text{h}_{\text{t,j,i,r}}\right) = \alpha(t) + \beta 1\bar{D}_{r,t} + \beta 2\bar{D}_{r,t-1} + \gamma X_{ir} + \delta P_{jir} + \pi Z_{ir} + U_i + U_r - - - - - (1)$$

$$\text{h}_{\text{t,j,i,r}} = pr\left(\text{Y}_{\text{t,j,i,r}} = 1 \;/\; \text{Y}_{\text{s,j,i,r}} = 0, s < t\right)$$

Where $\text{Y}_{\text{t,j,i,r}}$ is a binary response variable indicating whether a woman (i) from region (r) gave birth to the j^{th} child in the follow-up window (t). $\text{h}_{\text{t,j,i,r}}$ is the hazard of giving birth for a woman(i) of observed parity(j) at the interval(t), given that it has not occurred in the previous interval(s). $\alpha(t)$ is the baseline hazard which is specified as a step function(piecewise constant) by treating intervals (t) as a categorical variable.

[1] The gamma distribution is used because it is tend to be right-skewed(Burke et al.,2013)

The key explanatory variable $\overline{D}_{r,t}$ indicate whether the amount of summer rainfall, recorded in region (r) and in the in the calendar year associated with the respective follow-up interval (t), was below the threshold level, as described above. γ captures vector of parameters for socio-economic indicators(education, landownership and household wealth) of the women and/or her family. P_{jir} controls for a set of child level variables(survival status of previous child and birth parity). A number of background characteristics of the woman/household (such as age in the interval, religion and gender of the head) are included (Z_{tir}). The random terms Ui and Ur captures each individual i and region r , respectively, deviation from the conditional mean and assumed to be normally distributed with constant variance. Moreover, a set of interaction terms were also included to capture the differential impact of drought to different socio-economic groups and to understand the channels of the impacts.

Preliminary Results

Results obtained from the baseline multilevel models are reported in Table 2. The first column shows the bivariate relationship between each explanatory variable and the risk of giving birth to a child, adjusting only for the baseline hazard and unexplained variation at the individual and region levels. In the second column, we have estimated the effect of each predictor adjusting for the others children, mother and region level factors.

Results from model-II of table 2 show strong and significant differences in the level of fertility by socio-economic status of women. Higher levels of education of women and household wealth are associated with a substantial and statistically significant drop in the risk of childbirth. However, the risk of birth is not uniformly declining across the education groups and wealth quantiles. Relative to mothers with no education, the likelihood of giving birth decreases by about 8 percent for those with only some primary school and by 32 percent for those with at least completed primary education. In the contrary, the relative effect of household wealth is diminishing while moving to the upper quantile. Unlike wealth and education, land ownership is associated to higher fertility. In a given follow-up year, women from a landed family is 16-22 percent more likely to give birth than women from a landless family. The effect of size of the land owned by the family is also worth to consider where large landowners have significantly higher risk of giving a birth than small landowners. This can be associated with the higher demand for agricultural labor among large landowner families than to the smaller landowners.

As expected, child level predictors are also appeared as important predictors of fertility in rural Ethiopia. The results highlighted the very sizable impact of child mortality to birth timing. A woman whose previous child has died tend to have considerably higher risk of birth and the effect is even stronger if the previous child had died before celebrating its second birthday. This is consistent with replacement effect hypothesis that infant mortality is positively related to fertility (Schultz, 1996). It is also in line with the breast-feeding hypothesis that the death of the index child would cause shorter period of lactation amenorrhea. Understanding the precise reason for the strong effect of child mortality to shorter birth timing is, however, beyond the objective of this study. On the other hand, evidencing to the absence of parity specific birth controls in rural Ethiopia, the number of children ever born bound to have a statistically insignificant effect on the timing of the next birth. The exception is the transition from first to second birth, which is longer than the transition to any higher order births.

Table 2 Estimated odds ratios (and 95% confidence intervals) for the likelihood of giving the next birth, for women aged 15-49 ,with second to higher order births , in nine regions of rural Ethiopia.

Variables	Bi-variate		Model-II	
	OR	**95% CI**	**IRR**	**95% CI**
Drought(ref=no)	1.00		1.00	
Drought(t)	0.99	0.93-1.06	0.98	0.91-1.03
Drought(t-1)	0.87	0.81-0.92	0.86	0.80-0.90
Drought(t-2)	0.95	0.90-1.01	0.95	0.89-1.01
Women's Education				
No formal education(ref)	1.00		1.00	
Some primary	0.86	0.82-0.91	0.92	0.86-0.94
Completed primary+	0.60	0.53-0.68	0.68	0.64-0.75
Household Wealth				
Poor (ref)	1.00		1.00	
Medium	0.87	0.83-0.92	0.89	0.85-0.94
rich	0.82	0.78-0.86	0.86	0.79-0.86
Land Ownership				
Landless (ref)	1.00		1.00	
Small owners(>5ha)	1.16	1.09-1.24	1.12	1.18-1.32
Large Owners(>ha)	1.22	1.15-1.29	1.18	1.21-1.33
Status of Previous Child				
Alive(ref)	1.00		1.00	
Died before age 2	2.23	2.09-2.38	2.23	2.14-2.44
Died after age 2	1.42	1.30-1.56	1.41	1.26-1.51
Age of women at follow up				
15-24(ref)	1.00		1.00	
25-29	1.04	1.00-1.08	0.97	0.98-1.07
30-34	1.08	1.03-1.14	1.01	1.03-1.16
35-49	1.22	1.14-1.30	1.14	1.14-1.34
Children Ever Born				
first	0.81	0.78-0.86	0.87	0.78-0.86
Second(ref)	1.00		1.00	
third	1.03	0.97-1.09	1.02	0.93-1.04
Fourth	1.00	0.94-1.06	0.98	0.93-1.04
fifth	1.06	0.99-1.13	1.02	0.92-1.03
sixth or more	1.01	0.95-1.07	0.93	0.87-0.98
Baseline hazard	yes		yes	
Random Effects			**MOR**	
Level 3(region)			1.37	
Level 2(women)			1.35	
No. of children			25,699	
No. of women			7,491	

Note: OR = odds ratio; MOR = median odds ratio

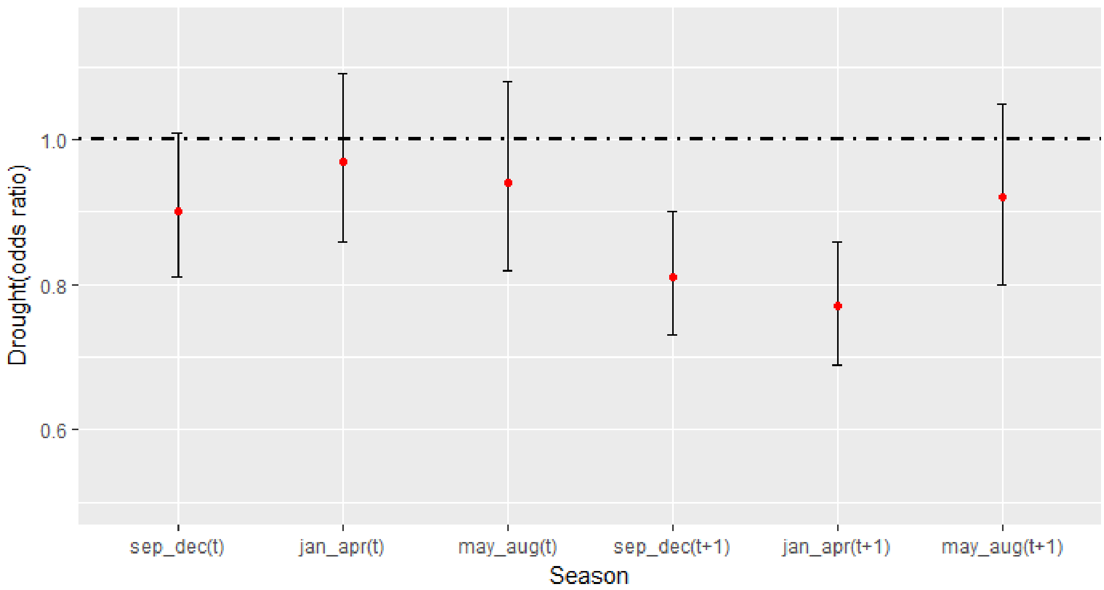
1.1. Drought and Birth Timing in Rural Ethiopia: Passive Response or Deliberate Control of Births?

The response of birth timing to short-term rainfall shocks, considering other individual and socio-economic determinates are also estimated and presented in table 2. Both the bi-variate and multivariate model estimates showed no significant response of fertility to rainfall shock with-in 12 months of the end of the rainy season. However, there is strong statistical evidence of delayed impact of drought on fertility. A drought season is associated with 13-14 percent lower fertility in the second year of the crisis and the effect die out after 24 months. This pattern is consistent with the result of Lindstron and Berhanu (1999) who studied the impact of famine and political crisis on fertility in northern Ethiopia. On the other hand, it is in sharp contrast to what Bengtsson and Dribe (2006) found for the pre-industrialized Scania county of Sweden where marital fertility responds immediately (within 12 months) to food price shocks with no significant impact in the second year of the shock.

Now, the immediate question is whether families are adjusting births-in the face of drought-deliberately and voluntarily or passively respond to drought in rural Ethiopia. As pointed out earlier, the mechanism that economic stress would affect birth timing can be identified by examining the time pattern of the responses. A quick response (with in the year of the crisis) is an indication of deliberate control of births. That is, families could forecast future economic misfortunes and planned births, accordingly, by using contraception, by abstinence or by induced abortion. On the other hand, a delayed response (in the following years after the crisis) is an evidence of passive response to economic difficulties either due to temporary migration and separation of spouses or due to malnutrition, which would lowered fecundity and spontaneous abortions. From the multilevel analysis, we have found no statistical evidence that rural Ethiopians could foresee bad harvests and planned births accordingly.

The delayed response of fertility to drought, as reported in table 2, is consistent with the malnutrition and /or temporary migration hypothesis. The response could be due to separation of spouses following the temporary migration of a partner in search of job somewhere else or lower fecundity due to malnutrition. Both are plausible mechanisms in the Ethiopian context. However, precise determination of the mechanism requires tracing the seasonal pattern of the response (Bengtsson and Dribe, 2006). Figure 3 visualize the seasonal pattern of the effect of rainfall shock in the first and second year of the drought. As it is mentioned above, there is no significant response in the first year of the shock indicating the absence of deliberate and planned response of births to crisis. On the other hand, the strongest response is observed about 12-15 months after the harvest (January-April of the second year). This is consistent with the malnutrition hypothesis. In rural Ethiopia, drought led food crisis is more serious few months after the harvest (in the dry seasons from April to early summer). This would cause reduction of sexual intercourse, lowered fecundity and fertility would decline nine months later (around January-April of the second year). As it is shown in figure 3, too little rains reduced fertility by about 24 percent in the second year of the drought. There is also evidence of migration as consumption smoothing mechanism in the area. Families who are affected by the drought would send member of the family(usually the husband) to near-by cities or cash crop producing area with the hope of a labor wage, which would enable them to remit back to the families and purchase seeds and farm equipment for the next production season (Dercon, 2002; IFPRI, 2010). Since no family could afford to lose even a small amount of crop, the migrated member of the family would move shortly after the harvest, which would cause separation of spouses and birth to decline nine months later (next harvest season). In line with this hypothesis, as displayed in the figure, fertility dropped by about 20 percent between September and December of the next year.

Fig3:Seasonal Pattern of fertility response to drought in rural Ethiopia



1.2. Socio-economic variation in the response of fertility to rainfall shocks

In order to explore the role of socio-economic status in mediating the impact of rainfall shocks, which would provide a proxy measure to living standard of the respective socio-economic group, a series of interaction models were estimated. Table 3 has presented the exact interaction effects (the full estimated models are reported in the appendix). Despite the socio-economic status of the woman, drought is found to have only a delayed impact, on fertility. Thus, below, we will discuss only the delayed impact of drought by socio-economic group of a woman.

In an agriculture-based society, land ownership is a vital component of socio-economic status of a family, which will determine the vulnerability of the family to short-term macroeconomic crisis. Bengtsson et al. (2006) showed that landless and semi-landless households are more vulnerable to food price shocks than large landowners are. Families with land above subsistence level are net producers, have higher demand for farm labor and their demand for additional child is less elastic to food price shocks. In rural Ethiopia, we have found a seemingly surprising result that large landowners are the one who are affected the most following a drought season. Families who own large arable land (>five hectare) lowered their fertility by about 17 percent within 12-24 months of bad summer rain. On the other hand, fertility of small landowners (less than five hectare) is about 11 percent lower and landless households shows no significant reduction in fertility. There can be at least two possible explanation for our findings. First: Landless and semi landless households engaged in off-farm activities, which is less sensitive to rainfall shocks, than landed households are (Woldenhanna and Oskam, 2001)2. Second: In Ethiopia, land is a state owned asset and the government could overtake it, if all members of the family migrate for an extended period following the harvest failure. To avoid the risk of losing the land, in the face drought and famines, landed families would ,thus, send an individual member of the family (usually the breadwinner) to nearby towns or other irrigation based agricultural area (Ezra, 2001). Thus, unlike the landless and semi

[2] Woldenhanna, T., and A. Oskam. 2001. Income diversification and entry barriers: evidence from the Tigray region of northern Ethiopia. Food Policy, 26: 351–365

Table 3: Estimated odds ratios (and 95% confidence intervals) for the effect of drought by socio-economic status of women and households.

Variables	Drought(t)		Drought(t-1)	
	OR	95% CI	OR	95% CI
Women's Education				
No formal education	0.96	0.90-1.03	0.84	0.79-0.90
Some primary	0.98	0.84-1.14	0.84	0.73-0.97
Completed primary+	0.91	0.72-1.14	0.93	0.75-1.16
Household Wealth				
Poor	0.89	0.81-0.97	0.74	0.68-0.81
Medium	0.96	0.83-1.12	0.94	0.81-1.09
rich	1.07	0.97-1.17	0.94	0.86-1.03
Land Ownership				
Landless	0.98	0.87-1.11	0.93	0.82-1.04
Small owners(<5ha)	1.01	0.88-1.05	0.85	0.75-0.97
Large Owners(>5ha)	0.94	0.86-1.02	0.81	0.75-0.88
Land Ownership **				
Landless	0.98	0.87-1.11	0.93	0.82-1.03
Own Land	0.95	0.89-1.03	0.82	0.77-0.88

Note: estimates are obtained models the same model as table 2 but includes interaction of drought and each socio-economic status separately.

landless families (who are mainly sharecroppers), drought induced separation of spouses could highly affect fertility of landed families.

As expected, the results confirm differential impact of drought by the educational attainment of woman. Failure of summer rain would significantly lower the fertility of women with no formal education while it did not significantly affect the better-educated groups. Fertility of uneducated women is about 15 percent lower in the second year of the drought while the fertility of women with incomplete primary education dropped insignificantly by only 7 percent and hardly any sign of reduction is observed for those with at least completed primary education. Similarly, material resource of the family is found to be a key moderator of vulnerability of households to drought induced harvest failure. Poorer family responds strongly, a decline of about 26 percent, while women from richer families show quite an insignificant response.

Was the Effect of Drought Parity Specific?

Under the plausible assumption of higher economic scale advantage of large families, the effect of food price shocks is likely to be lower to higher order births. That is, additional cost of children decreases with parity. Moreover, when household income declines following economic hardships, the first and most important response is to mobilize additional labor in to the labor market or migration. This advantage of additional labor could help larger family to adopt shocks more effectively. On the other hand, Studies in sub-Saharan Africa (for example; Boserup, 1985; Lesthaeghe & Jolly, 1995) observed crisis led fertility declines in high fertility environments. The main explanation is that as real income eroded due to recurrent macroeconomic crisis and civil war, an additional child become more expensive to larger families. In families with already large number of children, an additional child tends to reduce the household future consumption, thereby increasing household vulnerability in time of shocks (Haroon, 2009).

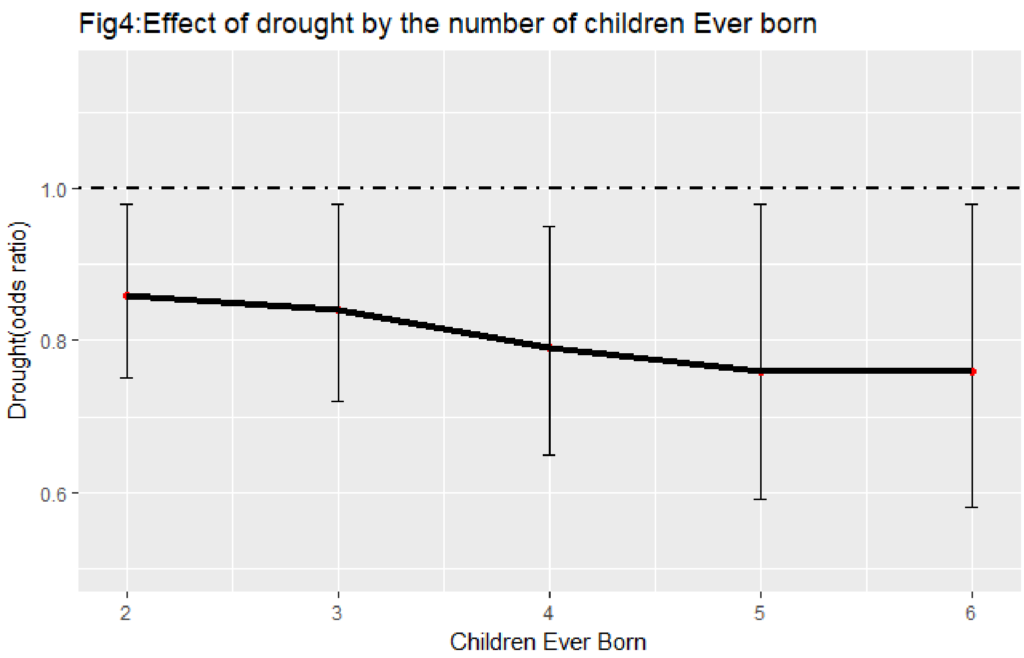


Figure 4 displayed the lagged effected of drought by the number of children ever born in the family, estimated from the interaction of birth parity and drought. The result shows that the effect of rainfall shock is stronger for women with larger number of children. Women who already bears three children would reduce their fertility by 16 percent, during drought, while women with only a single child are not significantly affected by the drought. This is in support the previous studies, which showed the existence of crisis led fertility declines in sub-Saharan Africa.

Preliminary Conclusion

Living standards and vulnerability to macroeconomic shocks remain a highly relevant topic to development policymaking. Direct measures of living standards ideally require data of sufficient length and information on income and consumption expenditures, which is rare in many developing countries. Demographers, thus, have proposed an effective and indirect measure of living standards defined as 'the ability to overcome short-term economic hardships'. If you can fulfil your long-term plans—to marry, to have children and to be in good health —in the face of acute changes in your environment, then you have a high standard of living. On the other hand, a person with low standard of living would respond to shocks by delaying marriage and births, out migration or may even experience death. Thus, tracing and comparing the demographic response of people to shocks would provide an alternative and effective measure of living standards.

This study explored the impact of local rainfall shocks on fertility in rural Ethiopia, where drought is a recurrent event, during the period 1974-2016. By combining individual level longitudinal data from demographic and household survey with regional level rainfall data, the degree and channel of responses of fertility to drought by different socio-economic group were analyzed. The result shows no immediate response of fertility to local rainfall shocks. This is an indication that families could not foresee shocks to make informed decisions about timing of childbirth using either contraception or induced abortion. The study rather find a clear and strong delayed response of fertility to drought. The more detailed analysis of this response revealed the importance of drought induced malnutrition and temporary separation of spouses. Drought would cause separation of spouses and lowered fertility later as individual members of the family are forced to migrate. Similar, in the later seasons of the drought food will be scarce and malnourished spouses would reduce sexual intercourse and lowered fecundity. The results show that large landowners, less educated and poorer families are strongly responding to drought. In addition, families with large number of children are more likely to involuntarily postponed births.

References

Admassie, A. (2013). The political economy of food price: The case of Ethiopia (No. 2013/001). WIDER Working Paper.

Bengtsson, T., & Ohlsson, R. (1985). Age-specific mortality and short-term changes in the standard of living: Sweden, 1751–1859. European Journal of Population/Revue européenne de Démographie, 1(4), 309-326

Bengtsson, T. ,et al. (2004). Life under Pressure. Mortality and Living standards in Europe and Asia, 1700-1900. The MIT press

Bengtsson, T., & Dribe, M. (2006). Deliberate control in a natural fertility population: Southern Sweden, 1766–1864. Demography, 43(4), 727-746.

Dercon, S. (2002). Income risk, coping strategies, and safety nets. The World Bank Research Observer.17(2):141–166.

Ezra, M. (2001). Rural out-migration in the drought prone areas of Ethiopia: A multilevel analysis. International Migration Review ;35(3):749–771.

Galloway, P. R. (1988). Basic patterns in annual variations in fertility, nuptiality, mortality, and prices in pre-industrial Europe. Population studies, 42(2), 275-303

IFPRI.(2012) . Crop Production in Ethiopia: Regional Patterns and Trends. ESSP II Working Paper

Kabeer, N. (2001). Ideas, economics and'the sociology of supply': explanations for fertility decline in Bangladesh. Journal of Development Studies, 38(1), 29-70.

Kinfu, Y. (2001). The quiet revolution: An analysis of change toward below-replacement level fertility in Addis Ababa. PhD Thesis, Australian National University

Lee, R. (1981). Short-term Variation: Vital Rates, Prices and Weather. In The Population History of England, 1541–1871. A Reconstruction, eds. Edward A. Wrigley, and Roger S. Schofield. London: Edward Arnold, 356–401.

Lee, R. (1990). The demographic response to economic crisis in historical and contemporary populations. Population Bulletin of the United Nations, (29), 1-15.

Lesthaeghe, R. (1989). Production and reproduction in sub-Saharan Africa: an overview of organizing principles.

Lesthaeghe, R. & Jolly, C. (1995) The start of the sub-Saharan fertility transitions: Some answers and many questions. Journal of International Development 7(1), 25–45.

Lindstrom, D. P., & Berhanu, B. (1999). The Impact of War, Famine, and Economic Decline on Marital fertility in Ethiopia. Demography, 36(2), 247-261.

Lockwood, M. (1995) Development policy and African demographic transition: Issues and questions. Journal of International Development 7(1–6), 1–24.

Muttarak, R. and Lutz,W. (2014). Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change? Ecology and Society 19(1): 42.

National Research Council.(1993). Demographic Effects of Economic Reversals in Sub-Saharan Africa. National Academic Press, Washington, DC.

World Bank.(2010) .Development and Climate Change: 2010 World Development Report .The World Bank, Washington DC, New York (2010)

United Nations.(2017). Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision